Planetology in laboratory using high power lasers: study of ices in the Mbar regime

Thanks to the development of powerful pulsed devices, such as high energy lasers, today it is possible to bring matter to extremely high temperature (~10^4K) and pressure (~10^6 bar) conditions, similar to those found in planets' interiors. Knowing the behaviour of matter at these extreme states is of extreme importance to unveil the internal structure of planets. This is not only of interest in its own but is also critical to understand the solar system history, formation and evolution. While recent achievements have improved description of terrestrial-like and Jupiter-like planets, icy giant planets remain poorly modelled mainly because of the lack of data on equations of state, chemical and transport properties of water and ice (H2O/CH4/NH3 system) at planetary interiors conditions. This leaves several lacunae in our understanding of our icy giant planets, Uranus and Neptune, in which ice comprises two thirds of their mass. Resolving this situation is even more urgent today as the discovery of exoplanets is incredibly active and Neptune-like planets seem to be very common in our galaxy.

Since 2016, our group has been working on this subject, bringing new experimental data on water, ammonia and C-H-N-O mixtures. We have used optical diagnostics to infer macroscopic measurements, such as equations of state. To go further in this research, we also use x-ray diagnostics to get microscopic insights and unveil the complex physics and chemistry into play. The last experiment was performed in December 2020 on the unique x-ray source of the LCLS x-ray free electron laser (XFEL) in Stanford.

In this stage, the student will learn and actively participate to the data analysis of these experiments, discussing the results in the context of established international collaborations. She/He will also have the opportunity to participate to similar experiments planned on LULI2000 for spring 2022.

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